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(54) Soft magnetic stainless steel having good cold forgeability.

(57) Soft magnetic stainless steel having good cold forgeability comprising, by weight, at most 0.015 % of C, at most 0.20 % of Si, at most 0.35 % of Mn, at most 0.010 % of S, 8 to 13 % of Cr, at most 0.020 % of Al, at most 0.0070 % of O, at most 0.0100 % of N and the balance of Fe and inevitable impurities, with a proviso that C + N content is at most 0.020 %. The stainless steel can be incorporated additionally at least one of 0.03 to 0.20 % of Ti, 0.002 to 0.02 % of Ca, at most 0.30 % of Bi, at most 0.040 % of Se, 0.002 % to 0.040 % of Te, 0.02 to 0.15 % of Zr, at most 2.5 % of Mo, at most 0.50 % of Cu, at most 0.50 of Ni, at most 0.20 % of Nb and at most 0.20 % of V. The stainless steel is suitable as magnetic core materials for use in electronic fuel injection devices, electromagnetic valves, magnetic sensors, etc.

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SOFT MAGNETIC STAINLESS STEEL HAVING GOOD COLD FORGEABILITY

The present invention relates to a soft magnetic steel material and, more specifically, it relates to a soft magnetic stainless steel having good cold forgeability together with good magnetic property, electric property, corrosion resistance and machinability which is suitable for material for use in electronic fuel injection devices, solenoid valves, magnetic sensors, etc.

Heretofore,0.1 %C steels have been used in most of magnetic core materials for use in electronic fuel injection devices, solenoid valves, magnetic sensors, etc., because 0.1 %C steels have soft magnetic property to some extent, as well as good cold forgeability that can be cold forged easily even into complicate shapes such as those of parts for the abovementioned application uses, and production cost and material cost are inexpensive.

On the other hand, there has been demanded in recent years those steel materials having the following three characteristics together, that is, capability of production in existent fabrication line used for 0.1 %C steels, that is, having forgeability as comparable with that of 0.1 %C steels, excellent corrosion resistance and, further, improved magnetic response (compliance of the material to external magnetic fields) in view of the demand for further higher performance. However, these demands can be satisfied only to the following extent by the existent technics at present.

At first, 0.1 %C steels are provided with corrosion resistance by applying Ni-P plating after cold forging. Although the materials have excellent cold forgeability (tensile strength 32 kgf/mm^2), they involve a drawback, when incorporated as a part in a device and used, in that platings are defoliated to cause clogging in valves during operation of the device to which they are assembled. In addition, the materials have a drawback that the electrical resistance is as low as 15 $\mu\Omega cm$ and the magnetic response is extremely poor. Further, referring to stainless steels, Fe-13Cr-1Si-0.25Al steels developed in the latter half of 1970's have been used since ten years or so as the materials of excellent cold forgeability. Although the materials have excellent corrosion resistance, high electric resistance and excellent response, the tensile strength is as high as 45 kgf/mm^2 and, accordingly, they can not be compared with 0.1 %C steels at all (tensile strength of 32 kgf/mm^2 and critical compressibility of 70 %). Accordingly, the materials can not be cold forged in the fabrication steps used for 0.1 %C steels. Subsequently, although improvement have been tried for the cold forgeability and the electromagnetic properties of 13Cr-1Si-0.25Al steels, those materials having cold forgeability superior to 13Cr-1Si-0.25Al have not yet been developed. In addition, since the material has fatigue strength at welded portion of as low as 25 kgf/cm^2 it can not satisfy the required quality of that of greater than 100 kgf/cm^2.

A primary object of the present invention is to provide soft magnetic stainless steel suitable to magnetic core materials for use in electronic fuel injection devices etc.

Another object of the present invention is to provide soft magnetic stainless steel having excellent cold forgeability such as tensile strength of less than 36 kgf/mm^2 and critical compressibility of greater than 70 % required for the magnetic core materials as electronic fuel injection devices, solenoid valves, magnetic sensors, etc..

A further object of the present invention is to provide soft magnetic stainless steel having excellent cold forgeability, showing excellent electric resistance of higher than 40 $\mu\Omega cm$, as well as excellent corrosion resistance, magnetic property, weldability, machinability and cold forgeability.

The soft magnetic stainless steel according to the present invention is based on the novel finding that has been found as a result of earnest studies made by the present inventors for the effects of various kinds of alloying elements on the cold forgeability, magnetic property, electric resistance and corrosion resistance of conventional soft magnetic stainless steels which are to be described later. When it is intended to obtain cold forgeability as comparable with that of 0.1 %C steels by the conventional metallurgical method, martensite structure is formed within the range of the chemical composition of stainless steels. On the other hand, it has been found by the present invention that single ferrite phase stainless steel can be obtained by extremely decreasing the total sum of the carbon content and the nitrogen content in the stainless steels. In the single ferrite phase steel in which the total sum of the carbon content and the nitrogen content is extremely decreased, cold forgeability much superior to that expected so far can be obtained by minimizing the amounts of Si, Al, S, O and like other elements each to a limit value, respectively, within the range necessary for the production of steel, thereby conducting purification of steel. Further, since the single ferrite phase can be obtained in the steel by extremely reducing the total sum of the C content and the N content, magnetic properties as comparable with those of other soft magnetic stainless steels can be obtained with no particular addition of Si, Al as in the conventional steels. Furthermore, by reducing the

Al content to at most 0.020 % along with the decrease for the each of the content of the elements and the purifying treatment, alumina formation during welding can be suppressed to remarkably improve the fatigue strength at the welded portion.

The present invention provides soft magnetic stainless steel having excellent cold forgeability comprising, by weight, at most 0.015 % of C, at most 0.20 % of Si, at most 0.35 % of Mn, at most 0.010 % of S, 8 to 13 % of Cr, at most 0.020 % of Al, at most 0.0070 % of O, at most 0.0100 % of N, and the balance of Fe and inevitable impurities, with a proviso that C + N content is at most 0.020 %.

The present invention also provides soft magnetic stainless steel having improved machinability and excellent cold forgeability comprising, by weight, at most 0.015 % of C, at most 0.20 % of Si, at most 0.35 % of Mn, 8 to 13 % of Cr, at most 0.020 % of Al, at most 0.0070 % of O, at most 0.0100 % of N, a member or members selected from the group consisting of 0.002 to 0.02 % of Ca, at most 0.30 % of Bi, at most 0.30 % of Pb, at most 0.040 % of S and at most 0.040 % of Se and the balance of Fe and inevitable impurities, with a proviso that C + N content is at most 0.020 % and, further, containing one or more of 0.002 to 0.040 % of Te and 0.02 to 0.15 % of Zr in case where one or more of S, Se is contained.

Further, the soft magnetic stainless steel for use in cold forging according to the present invention can be improved with the magnetic properties and the cold forgeability by incorporating from 0.03 to 0.20 % of Ti, as well as with the corrosion resistance by incorporating a member or members selected from the group consisting of at est 2.5 % of Mo, at most 0.50 % of Cu, at most 0.50 % of Ni, at most 0.20 % of Nb and at most 0.20 % of V.

The grounds for limitation on the composition of the steel according to the present invention will now be explained below.

C : at most 0.015 %

C is an element which impairs the cold forgeability due to solid solution reinforcement effect and adversely affects magnetic properties and, accordingly, it is desirable to reduce the content to a value as low as possible in the present invention and the upper limit thereof is defined as 0.015 %. For further improving cold forgeability and magnetic property, it is desirably to be at most 0.010 %. The lower limit for C is defined as 0.003 %.

Si : at most 0.20 %

Si is an element which impairs the cold forgeability due to the solid solution reinforcement effect. Since cold forgeability is considered most important in the present invention, the upper limit thereof is defined as 0.20 %, whereas the lower limit thereof is defined as 0.05 %.

Mn : at most 0.35 %

Since Mn remarkably impairs the corrosion resistance, magnetic property and cold forgeability, it is desirably less than 0.10 %. In view of the practical production, the upper limit thereof is defined as 0.35 %, while the lower limit thereof is defined as 0.15 %.

S : at most 0.010 %

S is contained as an impurity in steels but, since this is an element which impairs cold forgeability. The upper limit thereof is defined as 0.010 %, while the lower limit thereof is defined as 0.001 %.

Cr : 8 - 13 %

Cr is a fundamental element for improving corrosion resistance, electric resistance and magnetic property. Since such effects become insufficient; failing to obtain excellent corrosion resistance and electric resistance unless it is added in excess of 8 %, the lower limit thereof is defined as 8 %. However, since it impairs magnetic property and cold forgeability if contained in excess of 13 % the upper limit thereof is defined as 13 %.

Al : at most 0.020 %

Al is an element for reinforcement by solid-solubilization, which impairs cold forgeability and weldability. Since it is necessary to be restricted to at most 0.020 % in order to obtain fatigue strength of 100 kgf/cm^2 at the welded portion, the upper limit thereof is defined as 0.020 %. The lower limit for Al is defined as 0.003 %.

O : at most 0.0070 %

Since O forms an invading type solid-solution to remarkably impair cold forgeability, the content of O is desirably as low as possible. In view of the practical production, the upper limit th reof is defined as 0.007 %, while the lower limit thereof is

defined as 0.0030 %.

N : at most 0.0100 %

N is contained as an impurity in steels and, since it is effective for the improvement of cold forgeability and magnetic property by restricting the content to at most 0.0100 %. The upper limit thereof is defined as 0.0100 %, while the lower limit thereof is defined as 0.0030 %.

C + N : at most 0.020 %

Both of C and N are elements which remarkably impair magnetic property and corrosion resistance and impair cold forgeability due to the solid solution reinforcement effect. It is an object of the present invention to form an α -single ferrite phase with no addition of Si and Al to attain excellent cold forgeability with the tensile strength of less than 36 kgf/mm^2 and the critical compressibility of more than 70 % by restricting the content of C + N to at most 0.020 %. Accordingly, it is necessary to reduce the amount of C + N to a value as low as possible and the upper limit is defined as 0.020 %.

Ti : 0.03 - 0.20 %

Ti is an element which remarkably improves magnetic property such as the magnetic flux density and the coercive force, as well as fixing C + N into fine carbon nitrides in case where the C + N content is with an extremely low level of at most 0.020 %, thereby remarkably improving the cold forgeability such as tensile strength and the critical compressibility. In this meaning, this is an important element in the present invention. For attaining such effect, it is necessary that Ti has to be incorporated at least with 0.03 % and, accordingly, the lower limit thereof is defined as 0.03 %. However, since the effect is saturated even when Ti is incorprated in excess of 0.20 %, the upper limit thereof is defined as 0.20 %.

S : at most 0.040 %, Se : at most 0.040 %

S and Se are added for improving the machinability but since the addition thereof in a great amount impairs the cold forgeability, S is defined as 0.040 % for the upper limit and as 0.011 % for the lower limit, while Se is defined as 0.040 % for the upper limit and as 0.005 % for the lower limit.

Pb : at most 0.30 %, Bi : at most 0.30 %

Bi and Pb are elements which improve the machinability, but since the addition thereof in a great amount impairs cold forgeability, they are d fined as 0.30 % for the upper limit and as 0.05 % for the lower limit, respectively.

Ca : 0.002 - 0.02 %

Ca is added for improving the machinability and it is necessary to add in excess of 0.002 % for obtaining the above-mentioned effect. However, since cold forgeability is impaired if it is added in excess of 0.02 % the upper limit thereof is defined as 0.02 %.

Te : 0.002 -0.040 %

Te has an effect of eliminating the undesired effect of S and Se on cold forgeability and it is necessary to incorporate Te in excess of 0.002 % in order to obtain the effect. However, since the cold forgeability is rather impaired by the addition of a great amount, the upper limit thereof is defined as 0.040 %.

Zr : 0.02 - 0.15 %

Zr is an element which produces spherical MnS grains and improves cold forgeability and it has to be incorporated at least 0.02 %. However, since cold forgeability is impaired on the contrary by the addition of a great amount, the upper limit thereof is defined as 0.15 %.

Mo : at most 2.5 %, Cu : at most 0.50 %, Ni : at most 0.50 %, Nb : at most 0.20 %, V : at most 0.20 %

Mo, Cu, Ni, Nb and V in are elements which improve corrosion resistance. However, since magnetic property and cold forgeability are impaired when they are added in excess of 2.5 % for Mo, 0.5 % for each of Cu and Ni and 0.20 % for each of Nb and V, their upper limits are defined as 2.5 % for Mo, 0.5 % for Cu and Ni, respectively, and 0.20 % for Nb and V, respectively.
The lower limits for the elements are defined as 0.05 % for Mo, 0.10 % for Cu and Ni, respectively and 0.05 % for Nb and V, respectively.

The feature of the present invention will be explained more specifically referring to examples in comparison with conventional steels and compara-

tive steels. Table 1 shows the chemical composition in these tested steels.

In Tabl 1, tested steels Nos. 1 - 29 are soft magnetic stainless steels according to the present invention. No. 30 is a comparative example of low Cr content, No. 31 is a comparative example of high C, N, Si and Cr contents, No. 32 is a comparative example of high Al content and Nos. 33 and 34 are conventional steels.

20 For the tested steels shown in Table 1, heat treatment was applied by maintaining them at 900 °C for 2 hours and then cooling at a rate of 100 °C/hr and then the tensile strength, critical compressibility, magnetic flux density, coercive force, corrosion resistance, specific resistance and machinability were measured on each example.

The tensile strength was measured by using JIS No. 4 test specimens. The critical compressibility was determined by performing a compression test and measuring the upsetting rate at a 50 % cracking rate by using a notched test specimen of 14 mm diameter and 21 mm height, based on the cold upsetting performance test according to the standard (temporary standards) as provided by the Committee of Cold Forging of the Japanese Society of Plastic Rolling.

Table 1

No.	Chemical composition (wt%)								
	C	Si	Mn	S	Cr	Al	O	N	C+N
1	0.004	0.15	0.21	0.003	10.23	0.003	0.0050	0.007	0.011
2	0.005	0.05	0.22	0,004	12.35	0.005	0.0060	0.008	0.013
3	0.007	0.08	0.21	0.005	8.58	0.007	0.0055	0.005	0.012
4	0.007	0.14	0.18	0.008	11.65	0.006	0.0065	0.006	0.013
5	0.008	0.12	0.20	0.006	9.35	0.007	0.0070	0.004	0.012
6	0.006	0.11	0.20	0.005	10.61	0.009	0.0060	0.007	0.013
7	0.005	0.06	0.17	0.004	12.35	0.009	0.0050	0.007	0.012
8	0.004	0.13	0.21	0.005	8.67	0.013	0.0070	0.010	0.014
9	0.008	0.05	0.18	0.035	11.23	0.008	0.0060	0.006	0.014
10	0.007	0.09	0.20	0.005	11.65	0.005	0.0060	0.007	0.014
11	0.005	0.06	0.19	0.008	9.33	0.007	0.0050	0.005	0.010
12	0.007	0.13	0.17	0.028	12.36	0.006	0.0060	0.007	0.014
13	0.005	0.06	0.20	0.005	10.64	0.007	0.0070	0.004	0.009
14	0.006	0.06	0.21	0.006	9.55	0.008	0.0060	0.006	0.012
15	0.004	0.09	0.20	0.008	12.39	0.005	0.0050	0.005	0.009
16	0.003	0.13	0.22	0.015	11.28	0.013	0.0060	0.006	0.009
17	0.005	0.08	0.21	0.006	8.55	0.008	0.0070	0.009	0.013
18	0.006	0.12	0.20	0.005	9.64	0.013	0.0050	0.005	0.011
19	0.008	0.09	0.21	0.008	12.30	0.006	0.0060	0.006	0.014
20	0.004	0.12	0.22	0.005	11.68	0.005	0.0070	0.009	0.013
21	0.005	0.13	0.21	0.004	10.55	0.008	0.0050	0.006	0.011
22	0.004	0.08	0.21	0.006	11,27	0.005	0.0060	0.009	0.013
23	0.007	0.06	0.18	0.007	8.56	0.006	0.0070	0.007	0.014
24	0.005	0.08	0.20	0.004	10.58	0.005	0.0060	0.007	0.012
25	0.008	0.06	0.22	0.005	9.66	0.008	0.0050	0.005	0.013
26	0.003	0.13	0.19	0.004	12.36	0.007	0.0060	0.005	0.008
27	0.005	0.05	0.21	0.005	10.64	0.012	0.0055	0.008	0.013
28	0.004	0.14	0.20	0.005	11.65	0.008	0.0070	0.007	0.011
29	0.006	0.08	0.22	0.004	12.33	0.013	0.0060	0.006	0.012
30	0.007	0.16	0.28	0.005	6.54	0.018	0.0080	0.006	0.013
31	0.020	0.35	0.27	0.004	13.20	0.010	0.0050	0.020	0.040
32	0.007	0.18	0.33	0.007	11.28	0.050	0.0060	0.010	0.017
33	0.080	0.02	0.30	0.009	0.02	0.020	0.0110	0.020	0.060
34	0.01	0.95	0.32	0.010	12.06	0.240	0.0090	0.015	0.030

Table 1 (cont'd)

No.	Chemical composition (wt%)											
	Ti	Ca	Bi	Pb	Se	Te	Zr	Mo	Cu	Ni	Nb	V
1												
2												
3												
4	0.08											
5	0.15											
6		0.011		0.25								
7				0.16	0.032							
8			0.21									
9		0.008										
10			0.15									
11				0.18								
12												
13					0.024							
14					0.023	0.008						
15				0.10	0.020		0.11					
16					0.019		0.08					
17								1.23				
18									0.24			
19										0.37		
20											0.13	
21												0.08
22								0.84		0.27		
23								2.12				0.18
24											0.15	0.11
25	0.12		0.28	0.13								
26	0.08			0.10	0.024		0.05					
27	0.13								0.43	0.34		0.15
28	0.18	0.014		0.25		0.021		1.52		0.18		0.14
29	0.05		0.18		0.016		0.032	1.54	1.56		0.33	
30												
31												
32												
33												
34												

For the magnetic property, a ring specimen of 24 mm in outer diameter, 16 mm in inner diameter and 16 mm in thickness was prepared as a test specimen and the magnetic flux density and the coercive force were measured by using a DC type BH tracer.

Referring to the corrosion resistance, saline spray test was conducted using an aqueous 5 % NaCl solution to measure the rust forming rate and the evaluation was made as "◎" for less than 5 % and "O" those from 5 to 25 % with respect to the rust forming rate. The specific resistance was measured according to the Wheatstone bridge method using a wire of 1.2 mm diameter x 500 mm length as a test specimen.

For the machinability, drilling test was conducted by using a test specimen of 10 mm in thickness at a rotational speed of 725 rpm, with drill SKH diameter of 5 mm and under a load of 4 kg, and the time required for drilling was measured.

Table 2 shows the measured tensile strength (kgf/mm^2), critical compressibility (%), magnetic flux density (B_{20} (G)), coercive force (He (Oe)), corrosion resistance, specific resistance ($\mu\Omega cm$), machinability (second) and fatigue strength at welded portion (kgf/cm^2).

Table 2

No.	Tensile strength (kgf/mm^2)	Critical compressibility(%)	Fatigue strength at welded portion (kgf/cm^2)	Magnetic flux density B 20 (G)	Coercive resistance Hc (Oe)	Specific resistance ($\mu\Omega cm$)	Corrosion resistance	Machinability (sec.)
1	31.0	74	145	13780	1.32	46	○	20
2	31.6	73	135	13450	1.47	46	◎	20
3	28.9	76	130	14080	1.35	41	△	20
4	31.1	74	130	13550	1.28	48	○	20
5	29.3	76	130	13940	1.23	44	○	20
6	32.0	73	125	13720	1.35	46	○	6
7	33.9	71	125	13450	1.46	44	◎	9
8	30.8	74	115	14040	1.33	43	△	6
9	31.8	73	125	13640	1.40	44	○	8
10	32.6	72	140	13550	1.41	46	○	9
11	30.0	74	130	13970	1.36	42	○	8
12	34.6	70	130	13420	1.44	49	◎	9
13	32.0	73	130	13750	1.37	44	○	10
14	29.4	75	135	13930	1.36	42	○	8
15	31.7	73	135	13440	1.45	47	◎	5
16	31.4	73	115	13610	1.37	47	○	8
17	30.2	74	130	14080	1.36	41	○	20

Table 2 (cont'd)

No.	Tensile strength (kgf/mm^2)	Critical compressibility (%)	Fatigue strength at welded portion (kgf/cm^2)	Magnetic flux density B 20 (G)	Coercive resistance Hc (Oe)	Specific resistance ($\mu\Omega cm$)	Corrosion resistance	Machinability (sec.)
18	31.1	74	110	13890	1.32	44	◎	20
19	33.2	72	135	13440	1.45	47	◎	20
20	31.9	73	135	13540	1.40	47	○	20
21	31.0	74	130	13730	1.34	46	○	20
22	33.1	72	135	13620	1.39	45	◎	20
23	31.8	73	135	14090	1.37	40	◎	20
24	31.5	74	135	13740	1.36	44	○	20
25	30.7	74	130	13900	1.36	42	○	5
26	31.0	74	130	13400	1.44	49	◎	6
27	32.3	73	115	13740	1.38	44	◎	20
28	32.9	72	130	13540	1.39	48	◎	5
29	33.9	71	115	13440	1.45	47	◎	6
30	30.0	75	105	14370	1.45	39	×	20
31	39.0	62	110	13130	1.43	51	◎	20
32	33.1	72	40	13560	1.33	51	○	20
33	31.2	70	100	15400	2.60	15	×	20
34	44.9	45	25	13040	1.10	75	○	8

As can be seen from Table 2, the comparative example No. 30 of low Cr content is poor in lectric resistance and in corrosion resistance. The comparative example No. 31 of high C, N, Si and C contents are poor in tensile strength, poor in critical compressibility and thereof inferior in cold forgeability, and the comparative example No. 32 of high Al content is inferior in fatigue strength at welded portion.

On the other hand, although the comparative steel No. 33 corresponding to pure iron shows good cold forgeability, it is poor in corrosion resistance and the conventional steel No. 34 corresponding to 13Cr -1Si -0.25Al has a high tensile strength, poor critical compressibility and poor critical strength at welded portion.

On the contrary, Nos. 1 - 29 as steels according to the present invention show excellent cold forgeability having tensile strength of less than 35 kgf/mm^2 and critical compressibility of greater than 70 % as well as they show excellent weldability having fatigue strength at welded portion of greater than 110 kgf/cm^2, show high electric resistance and corrosion resistance, as well as they are satisfactory also in view of the magnetic property, by which the effects of the present invention can be confirmed.

As has been described above specifically, the soft magnetic stainless steels for use in cold forging according to the present invention are remarkably improved with cold forgeability while maintaining the excellent electric resistance, the magnetic property and the corrosion resistance as they are obtained by reducing the amount of Si and Al, and reducing solid solution reinforcing element such as C, N and O to a value as low as possible.
In addition, the machinability is improved without impairing the cold forgeability by adding, in combination, S, Se, Pb, Te, Zr and Ti as required. The present invention provides corrosion resistant soft magnetic steel suitable to magnetic core parts prepared by the cold forging such as for pulse-actuated type electronic fuel injection devices, the electromagnetic valves, etc. and have highly practical usefulness.

Claims

1. Soft magnetic stainless steel having good cold forgeability comprising, by weight, at most 0.015 % of C, at most 0.20 % of Si, at most 0.35 % of Mn, at most 0.010 % of S, 8 to 13 % of Cr, at most 0.020 % of Al, at most 0.0070 % of O, at most 0.0100 % of N and the balance of Fe and inevitable impurities, with a proviso that C + N content is at most 0.020 %.

2. The soft magnetic stainless steel as claimed in Claim 1 additionally including, by weight, 0.03 - 0.20 % of Ti.

3. The soft magnetic stainless steel as claimed in Claim 1 additionally including, by weight, a member or members selected from the group consisting of at most 2.5 % of Mo, at most 0.50 % of Cu, at most 0.50 % of Ni, at most 0.20 % of Nb and at most 0.20 % of V.

4. The soft magnetic stainless steel as claimed in Claim 3 additionally including, by weight, 0.03 - 0.20 % Ti.

5. Soft magnetic stainless steel having good cold forgeability comprising, by weight, at most 0.015 % of C, at most 0.20 % of Si, at most 0.35 % of Mn, 8 to 13 % of Cr, at most 0.020 % of Al, at most 0.0070 % of O, at most 0.0100 % of N, a member or members selected from the group consisting of 0.002 to 0.02 % of Ca, at most 0.30 % of Bi, at most 0.30 % of Pb, at most 0.040 % of S, at most 0.040 % of Se, and a member or members selected from the group consisting of 0.002 to 0.040 % of Te and 0.02 to 0.15 % of Zr where one or more of S and Se is contained, and the balance of Fe and inevitable impurities, with a proviso that C + N content is at most 0.020 %.

6. The soft magnetic stainless steel as claimed in Claim 5 additionally including, by weight, 0.03 - 0.20 % of Ti.

7. The soft magnetic stainless steel as claimed in Claim 6 additionally including, by weight, a member or members selected from the group consisting of at most 2.5 % of Mo, at most 0.50 % of Cu, at most 0.50 % of Ni, at most 0.20 % of Nb and at most 0.20 % of V.

8. The soft magnetic stainless steel as claimed in any of Claims 1 to 7, wherein as far as any of the following elements is present the lower limit thereof determined by weight is:
C = 0.003
Si = 0.05
Mn = 0.15
S = 0.001
Al = 0.003
O = 0.0030
N = 0.0030
Se = 0.005
Pb = 0.05
Bi = 0.05
Mo = 0.05
Cu = 0.10
Ni = 0.10
Nb = 0.05
V = 0.05 .

European Patent Office

EUROPEAN SEARCH REPORT

Application number

EP 88121858.0

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl 4)
A	US - A - 4 753 692 (KUROKI) * Abstract; claims 1-8 * --	1,5	H 01 F 1/04
A	US - A - 4 661 174 (MIYOSHI) * Abstract; claims 1-5 * --	1,5	
A	US - A - 4 116 727 (MAJOS) * Abstract; claims 1-11 * ----	1,5	
			TECHNICAL FIELDS SEARCHED (Int. Cl.4)
			H 01 F 1/00

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
VIENNA	02-10-1989	VAKIL

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
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L : document cited for other reasons

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